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GEOTECHNICAL MATERIALS DATABASE FOR EMBANKMENT DESIGN AND CONSTRUCTION

This report describes the research conducted to develop the South Carolina Department of Transportation (SCDOT) Geotechnical Materials Database (GMD) for embankment design and construction. The identification and selection of local borrow soils with established engineering properties is a critical phase in embankment design and construction. Normally, designers and contractors must conduct expensive and time-consuming geotechnical tests to determine engineering properties, or if available, use their own prior experience. The SCDOT GMD provides an electronic resource with a compilation of the specific engineering properties of potential borrow materials available throughout South Carolina. It was created using data from three sources: 1) available information from the SCDOT Engineering District offices on borrow pits that have been used for embankment construction; 2) available triaxial test data on soil samples acquired from existing embankments; and 3) comprehensive experimental program conducted using bulk samples acquired from a select number of borrow pits representing different regions of the state.

Geographical and geotechnical information were gathered from 197 borrow pits across the state of South Carolina. Geotechnical data were available for 140 of the 197 borrow pits, although in most cases, the data were limited to soil descriptions that often included USCS and/or AASHTO soil classifications. In a few cases, data were provided on particle size distribution and/or soil compaction. It was determined that 37 of the 197 borrow pits were either active or accessible, and seventeen (17) were selected for sampling and testing. Three bulk samples were collected at each borrow pit. The locations of each sampling point were based on soil maps produced using the USDA Web Soil Survey, which delineates the soil units present in each borrow pit. Tests for physical properties included visual manual identification, moisture content, specific gravity, particle size distribution, liquid limit, plastic limit, and soil classification. Tests for mechanical properties included standard Proctor compaction, direct shear, and triaxial compression, which were used to determine the most critical soil properties including maximum dry density ($\gamma_{d,max}$), optimum water content (w_{opt}), effective friction angle, ϕ' and effective cohesion, c'. Tests for chemical properties included soil pH, soil resistivity, chloride content, and sulfate content. Test methods were performed according to AASHTO standard specifications, with two exceptions for chloride and sulfate contents, which were determined using USEPA test methods.

The SCDOT has created two categories of borrow soils, Group A and Group B, based on the geological environment in South Carolina. The 17 borrow pits selected for experimental studies are distributed within these two groups. Group A soils are located north and west of the Fall Line in the Blue Ridge and Piedmont physiographic geologic units. Here, most soils were formed as residuum of the underlying parent rock and therefore reflect the properties of the weathered parent material. These residual soils are often difficult to place and compact during embankment construction, and can be susceptible to erosion. Group B soils are located south and east of the Fall Line in the Coastal Plain physiographic geologic unit. Coastal Plain units are identified with age and progress from the present coastline, where the youngest deposits reside, northwest toward Columbia. A diverse assortment of sands appears throughout the Coastal Plain region.

The SCDOT GMD shows that the predominant USCS and AASHTO soil classifications differ between Group A and Group B soil deposits, as expected. In general, the soils in Group B have lower fines content than those in Group A. SP-SM and SW-SM soils are common in Group B but are not found in Group A. The fines content of SM and SC soils in Group B does not exceed 32%; whereas, all but one of the SM soils in Group A has at least 35% fines. In terms of AASHTO classifications, Group B soils range from A-1 to A-4 and there are no soils with A-5 or higher classifications. In Group A, the preponderance of soil samples are classified as A-5 or higher.

The compaction characteristics are a function of soil classification. In Group A, the A-2-4 and A-4 soils have the highest $\gamma_{d,max}$ (> 115 pcf in some cases) and lowest w_{opt} required for compaction. The A-5 and A-7-5 soils have the lowest $\gamma_{d,max}$ (< 100 pcf in some cases) and require the highest w_{opt} for compaction. More than half of the Group A soils have $w_{opt} \geq 20\%$. Mica was observed to be present in some of these soil samples. In Group B, the A-1 and A-2 soil groups tend to produce a higher $\gamma_{d,max}$ at lower w_{opt} than the A-3 and A-4 soil groups. All of the Group B soil samples with $\gamma_{d,max}$ of at least 110 pcf are in the A-1 and A-2 soil groups. All of the Group B soils have $w_{opt} < 20\%$.

On average, Group A soils have higher effective friction angles than Group B soils. The results for Group A soils are in agreement with published shear strength parameters for Piedmont residual soils that indicate an average effective friction angle of 35.2° with a ± 1 standard deviation range of $29.9° < \phi' < 40.5°$. In Group B soils, the effective friction angles for SC, SC-SM, CL and ML soils range from $28° < \phi' < 32°$, which is consistent with prior SCDOT experience in the Coastal Plain. Most of the SM soils, however, were found to have higher effective friction angles ranging from $34° < \phi' < 36°$.

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